

Global Power System Trends and Implications for the Future: a CIGRE perspective

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Cigre Study Committee C1



CIGRE: Strategic Directions



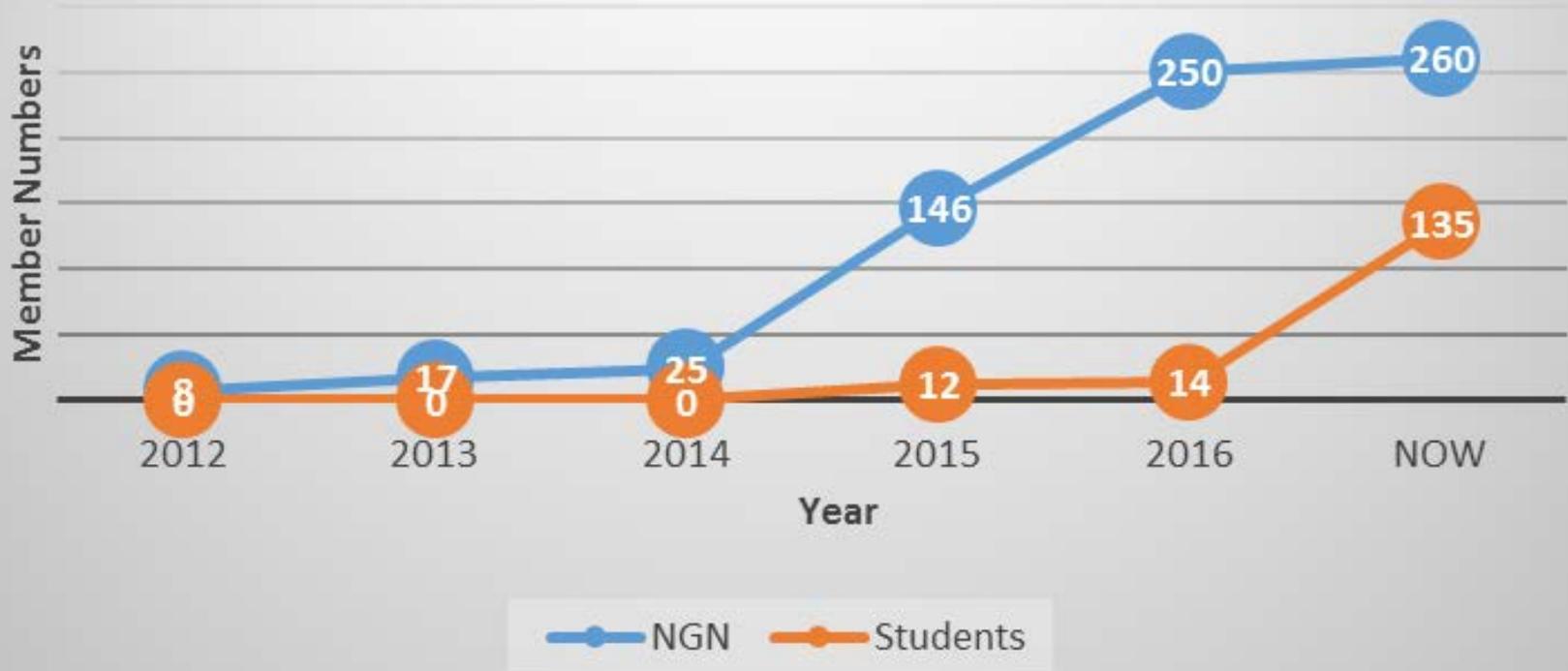
NGN

Next Generation Network

“Australia's next generation of power engineers”

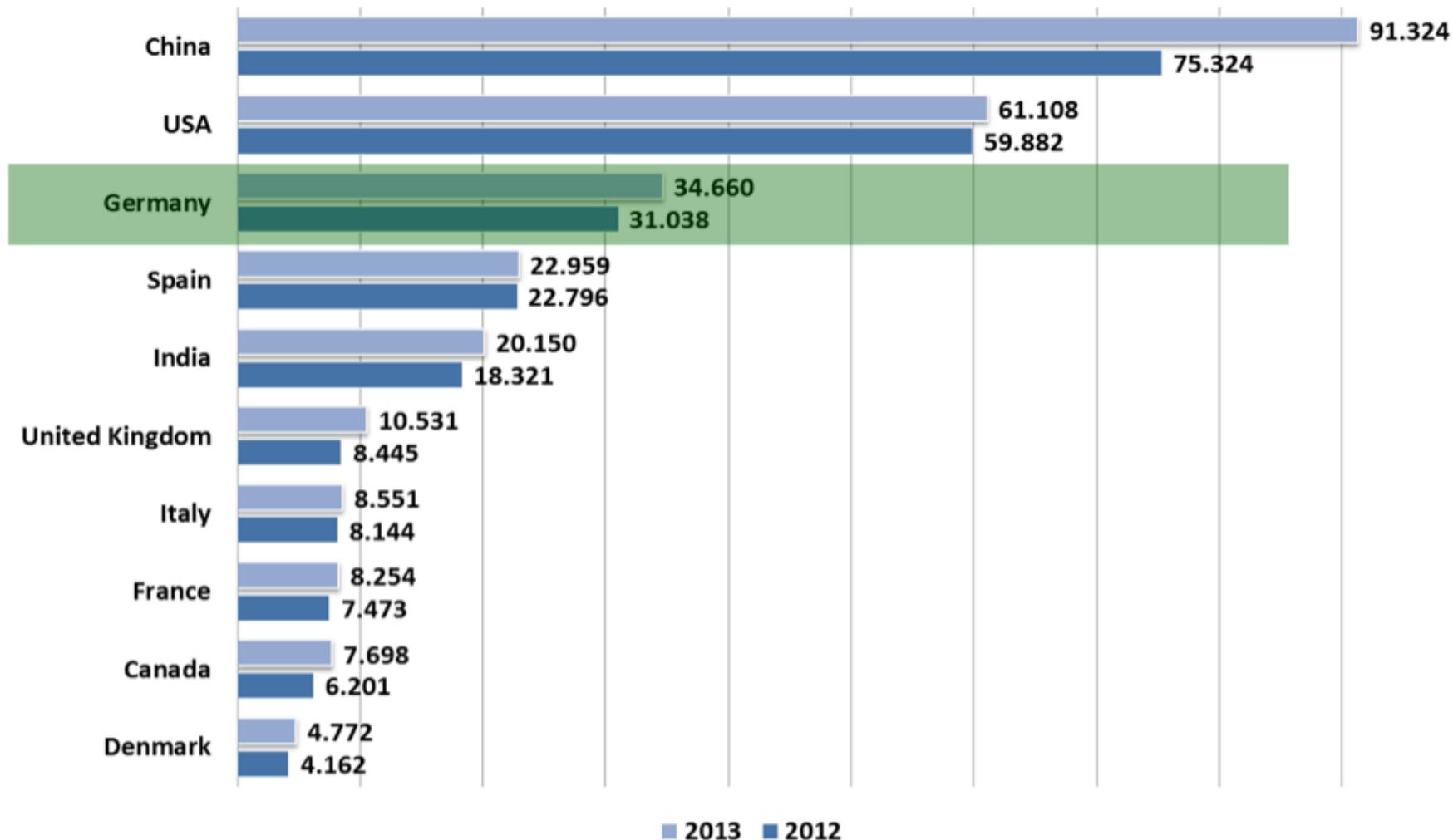


CIGRE Australia NGN and Student Membership



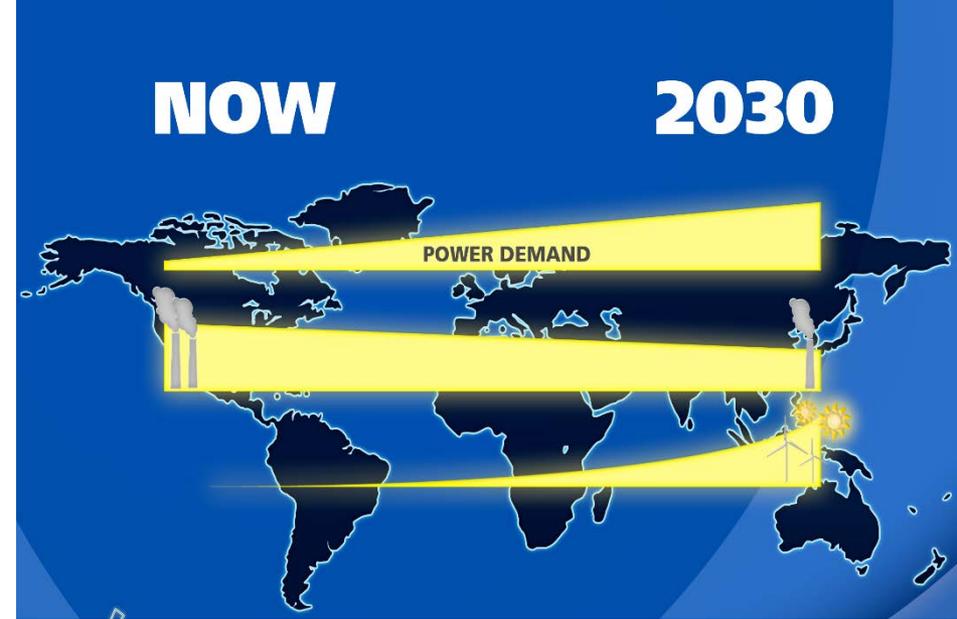


Top 10 Countries by Total Wind Capacity [MW] installed (2012 and 2013)



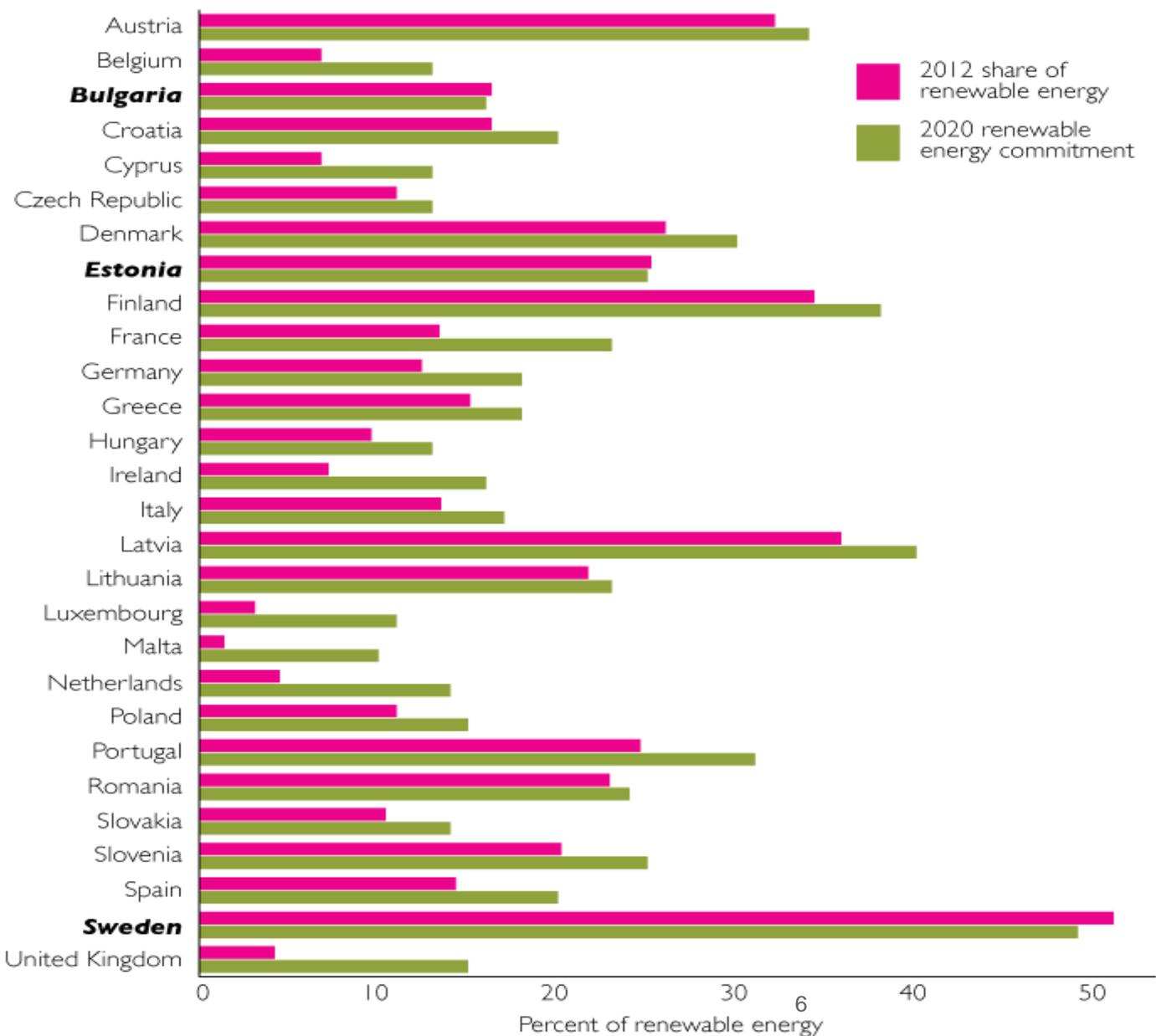
Source: World Wind Energy Association

EU – new 2030 targets

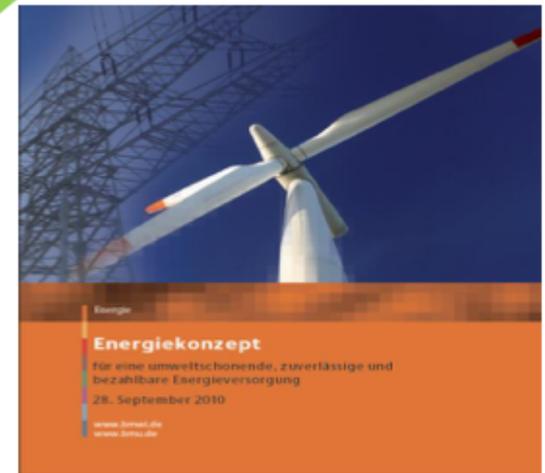
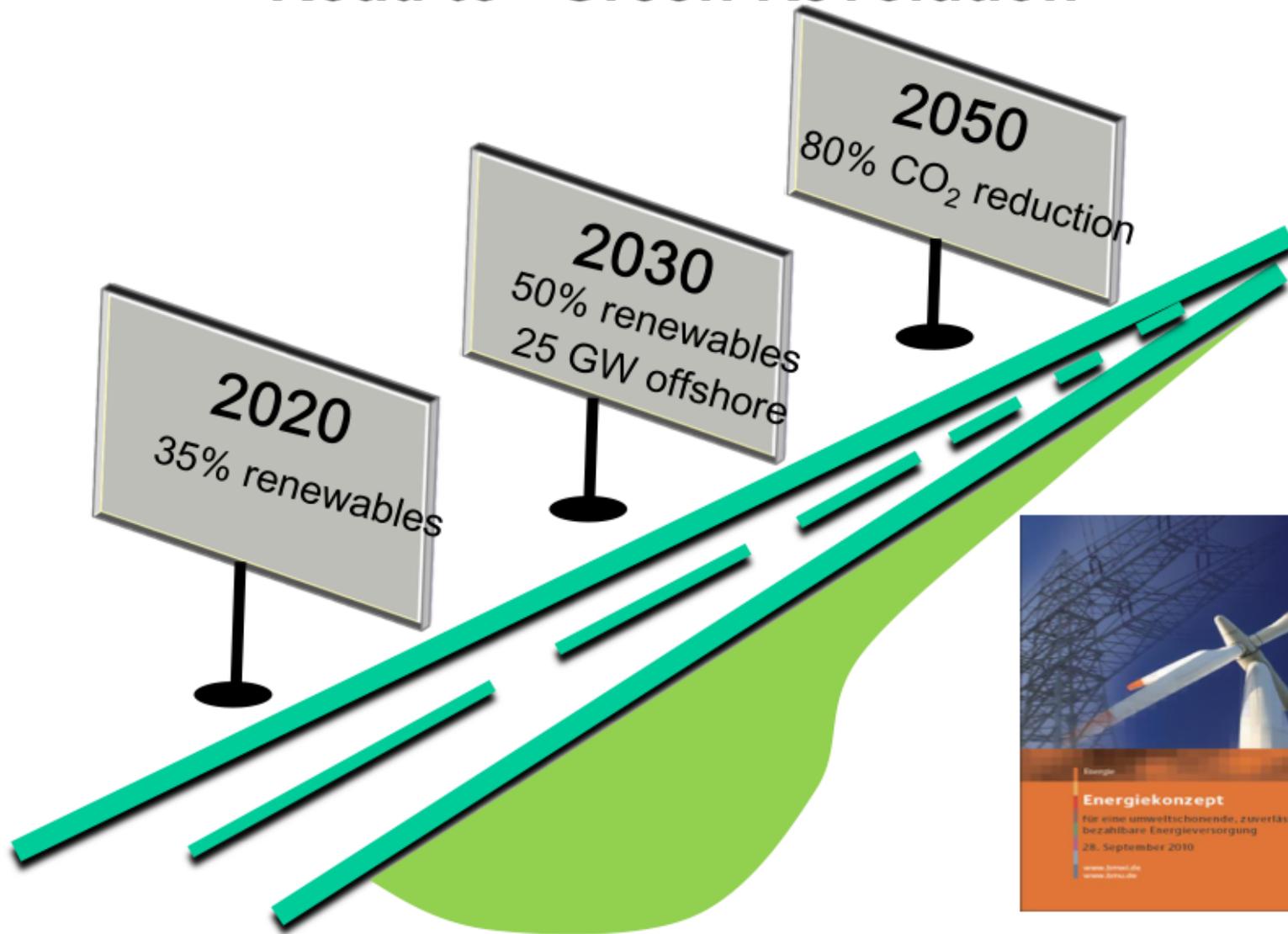


- At least 40% cuts in **greenhouse gas emissions** (from 1990 levels)
- At least 27% share for **renewable energy**
- At least 27% improvement in **energy efficiency**

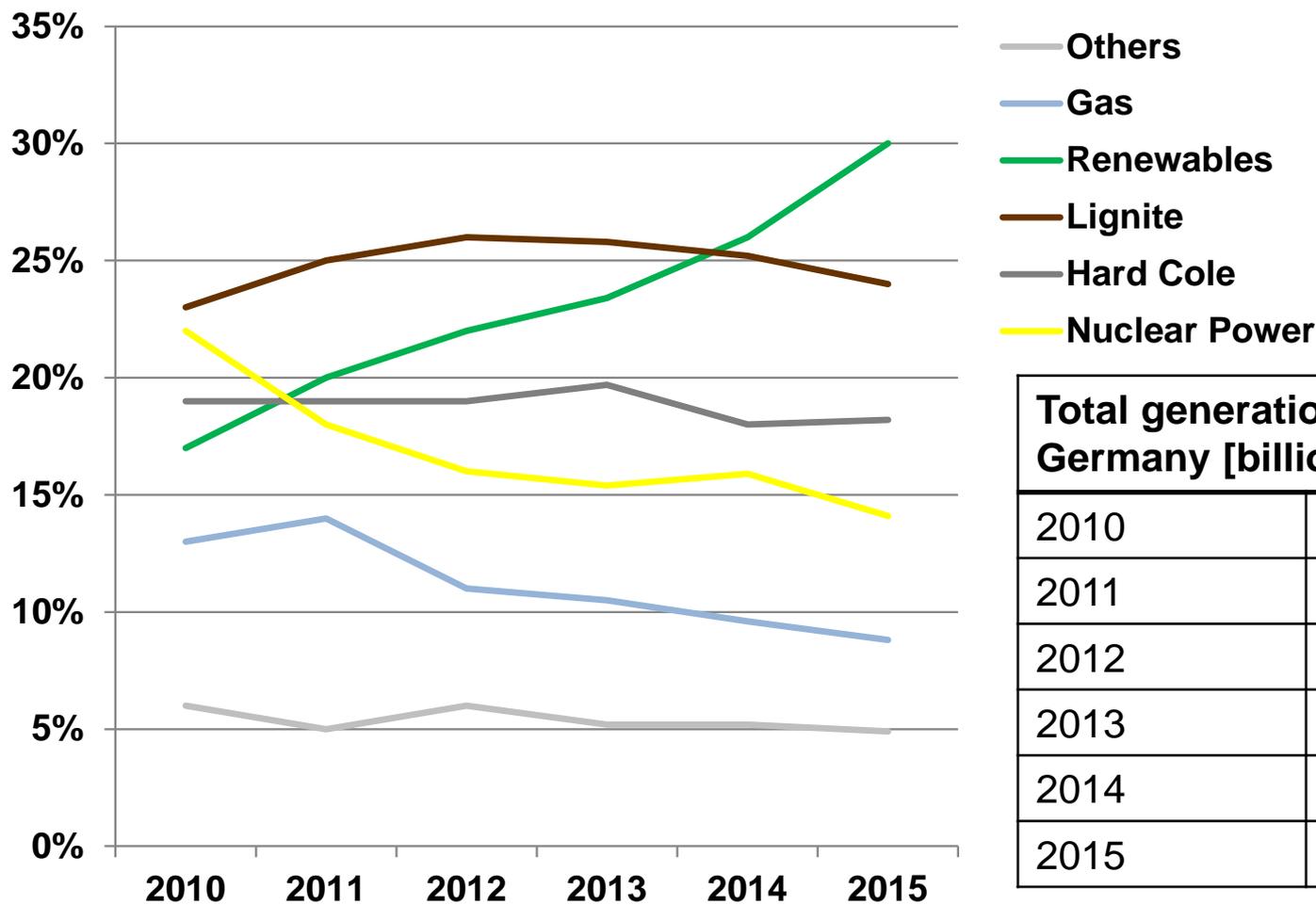
EUROPEAN UNION MEMBERS RENEWABLE ENERGY IN 2012 vs. 2020 COMMITMENTS



Germany, quo vadis? Road to “Green Revolution”



Development of Generation Capacity in Germany since 2010 (share of primary energy)



Total generation in Germany [billion kWh]:	
2010	605
2011	612
2012	617
2013	629
2014	610
2015	647

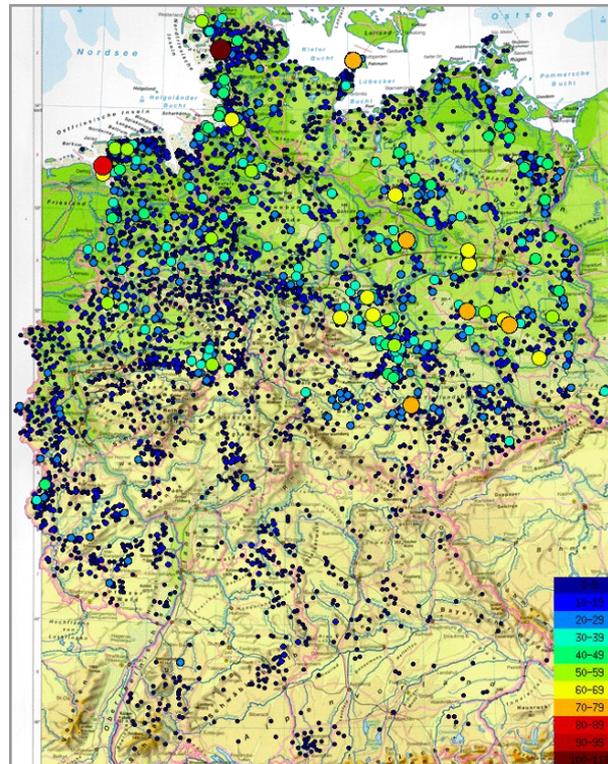
Source: Amprion GmbH



Impacts of Renewable Generation on Grid Security (1)

Renewable Generation leads to an unusual power flow in the Grid:

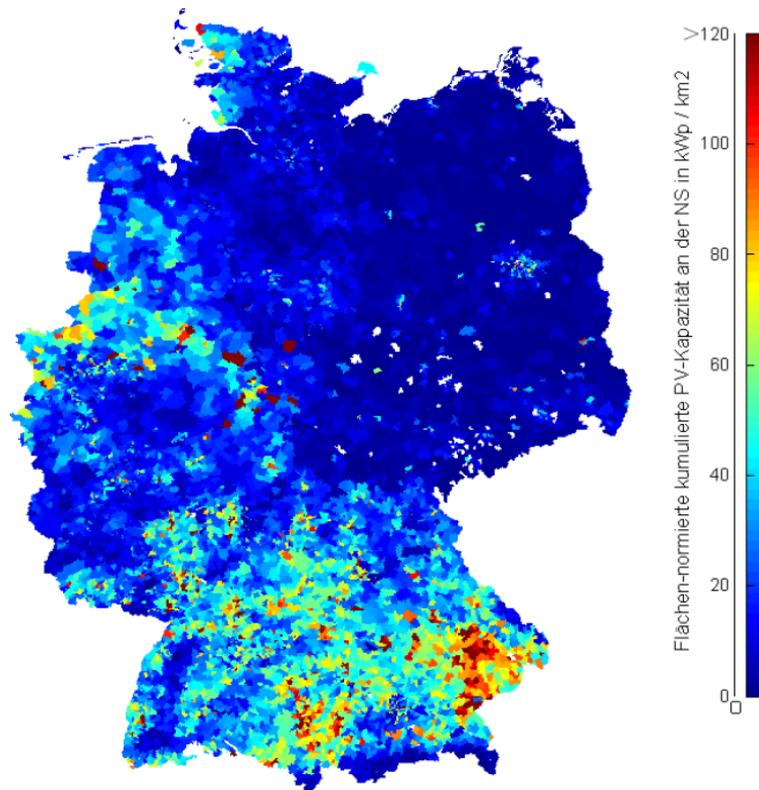
- In Germany Wind generation is installed in the northern and eastern part of the country
- High Wind power leads to bulk energy flows from North to South because most industry is concentrated in southern part of Germany



Impacts of Renewable Generation on Grid Security (2)

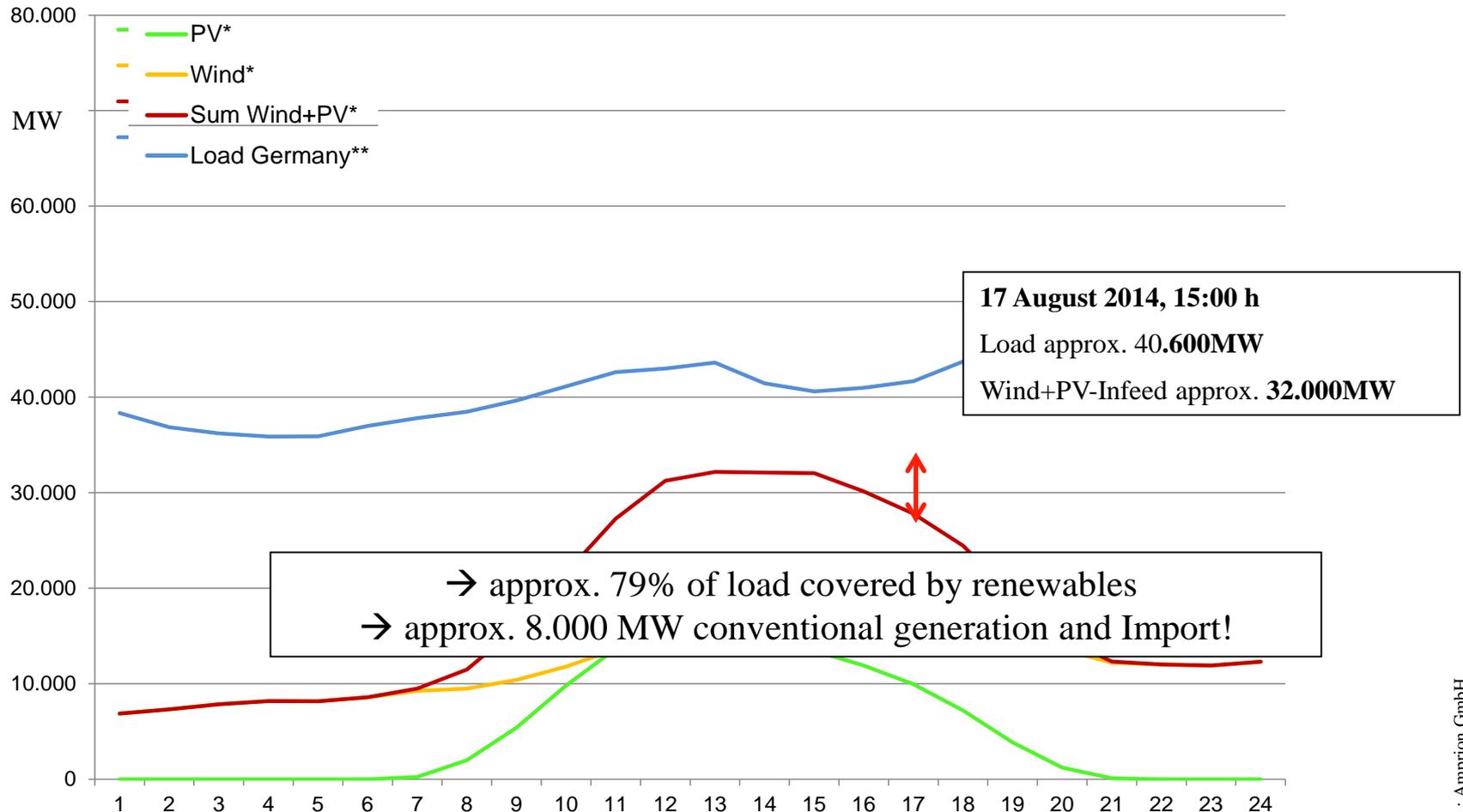
Renewable Generation leads to an unusual power flow in the Grid:

- In Germany PV generation is installed in the southern part of the country
- High PV power leads to bulk energy flow in DSO grid and from DSO to TSO



Wind and Solar Infeed vs. Load in Germany

Time: Sunday, 17 August 2014 (day with highest share of renewable energy covering load)



Data Source: * Netz-Transparenz ** ÜNB

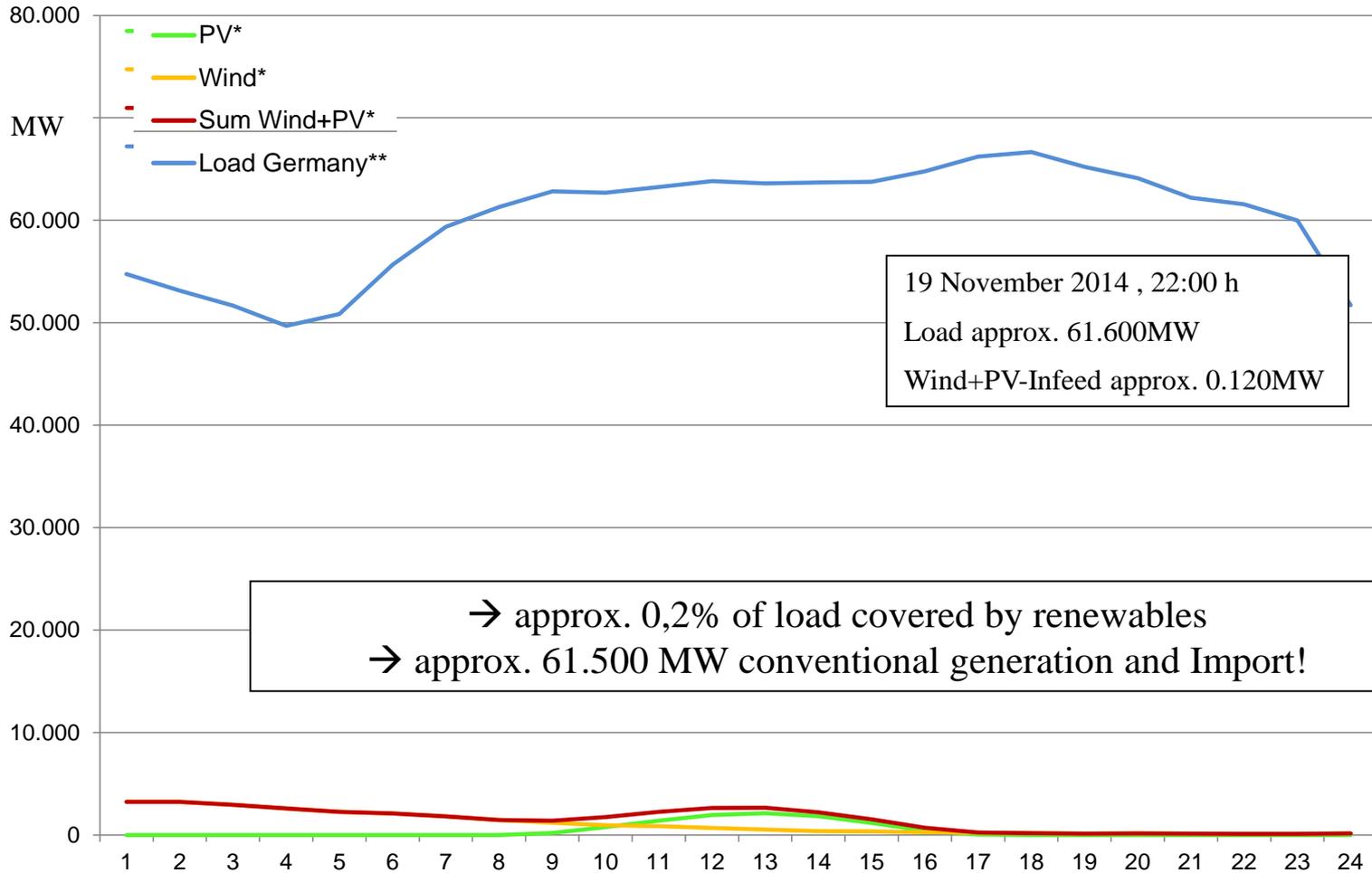
h-values



Source : Amprion GmbH

Wind and Solar Infeed vs. Load in Germany

Time: Wednesday, 19 Nov. 2014 (day with lowest share of renewable energy covering load)



→ approx. 0,2% of load covered by renewables
 → approx. 61.500 MW conventional generation and Import!

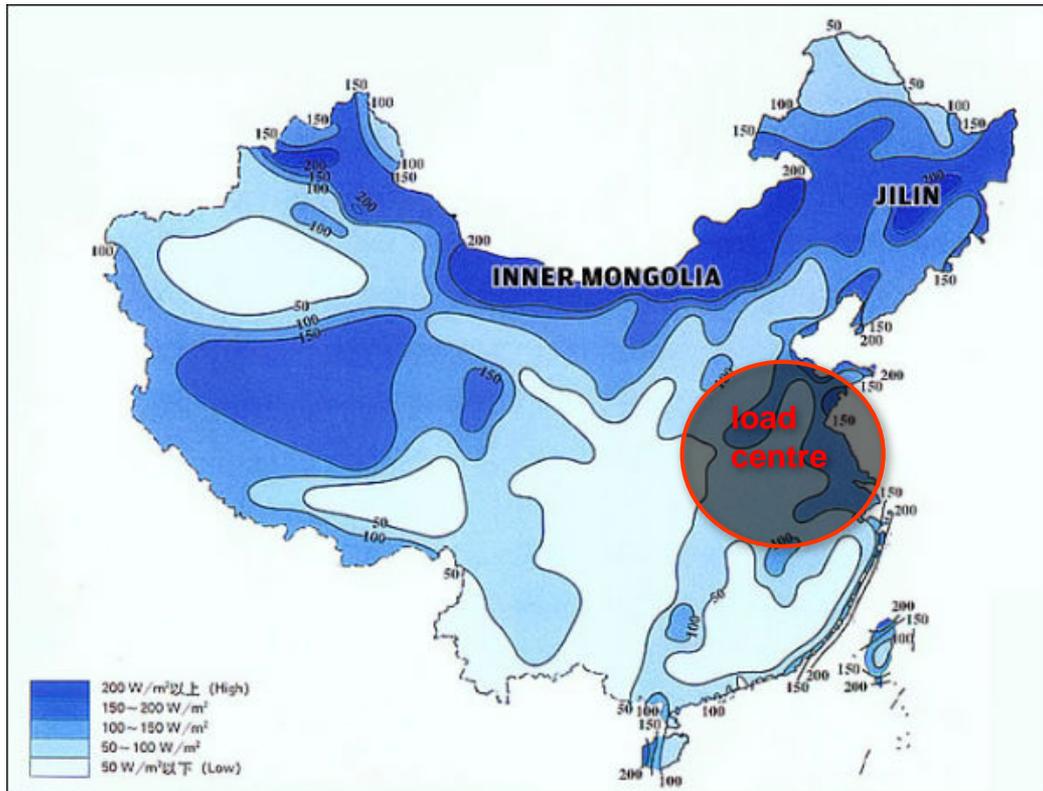
Source : Amprion GmbH



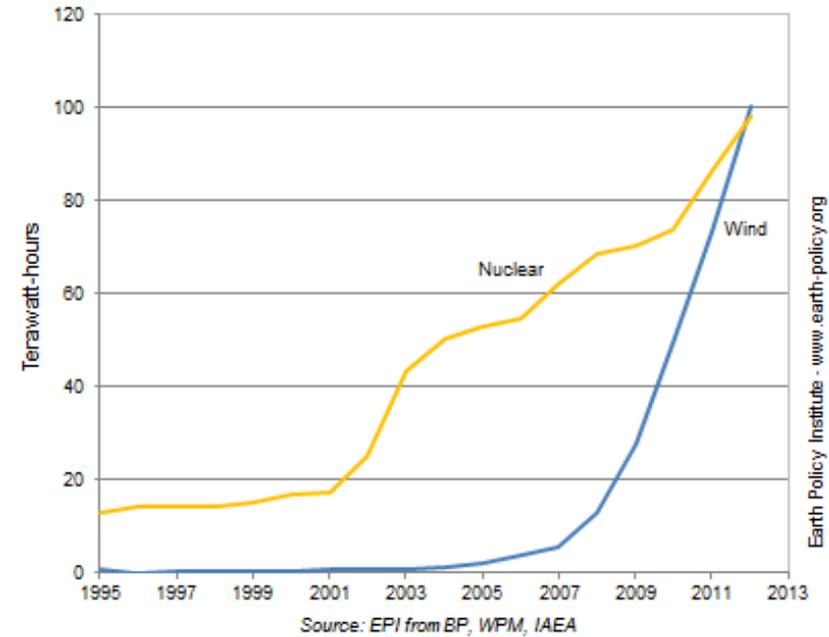
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Data Source: * Netz-Transparenz ** ÜNB

China's Push into Wind



Wind- and Nuclear-generated Electricity in China, 1995-2012

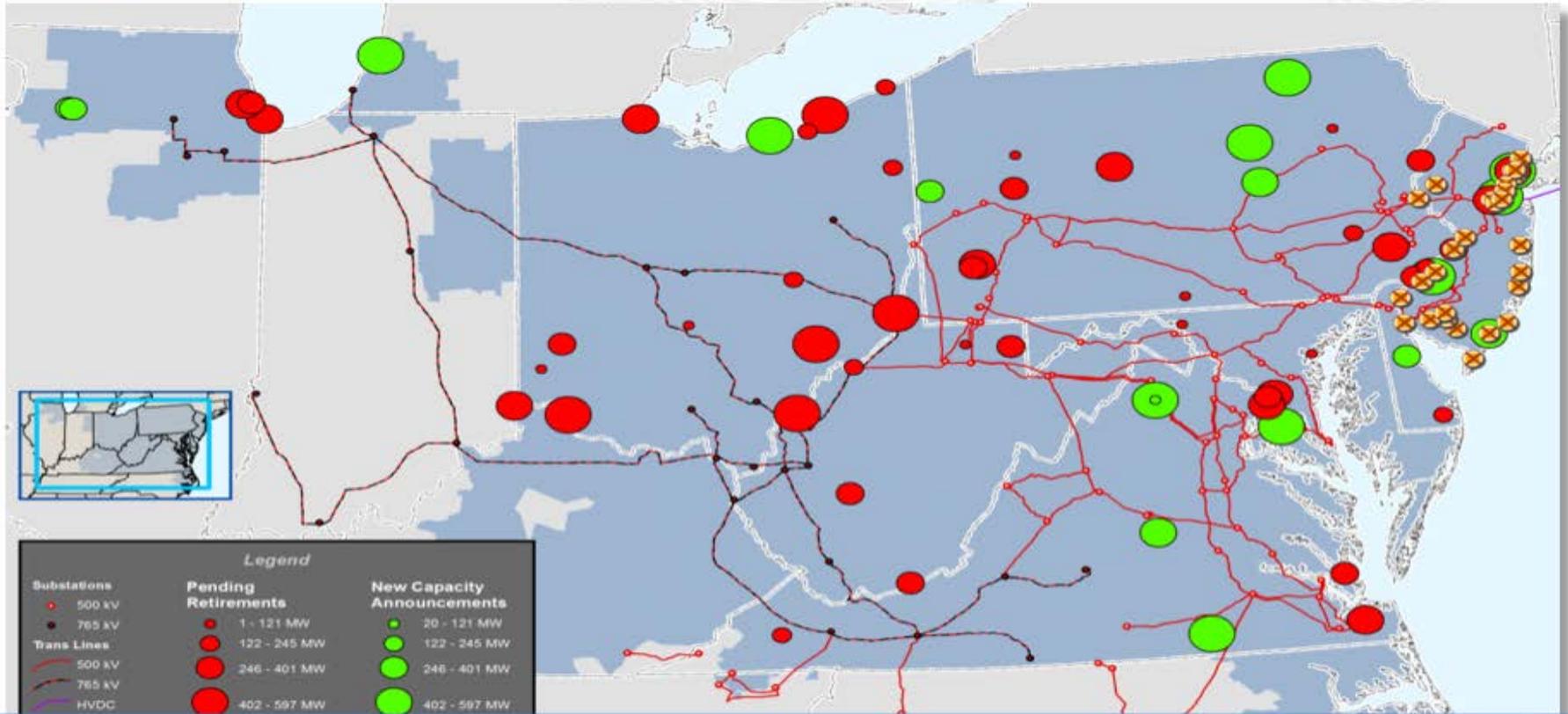


China Three Gorges Dam



Shale Gas Revolution



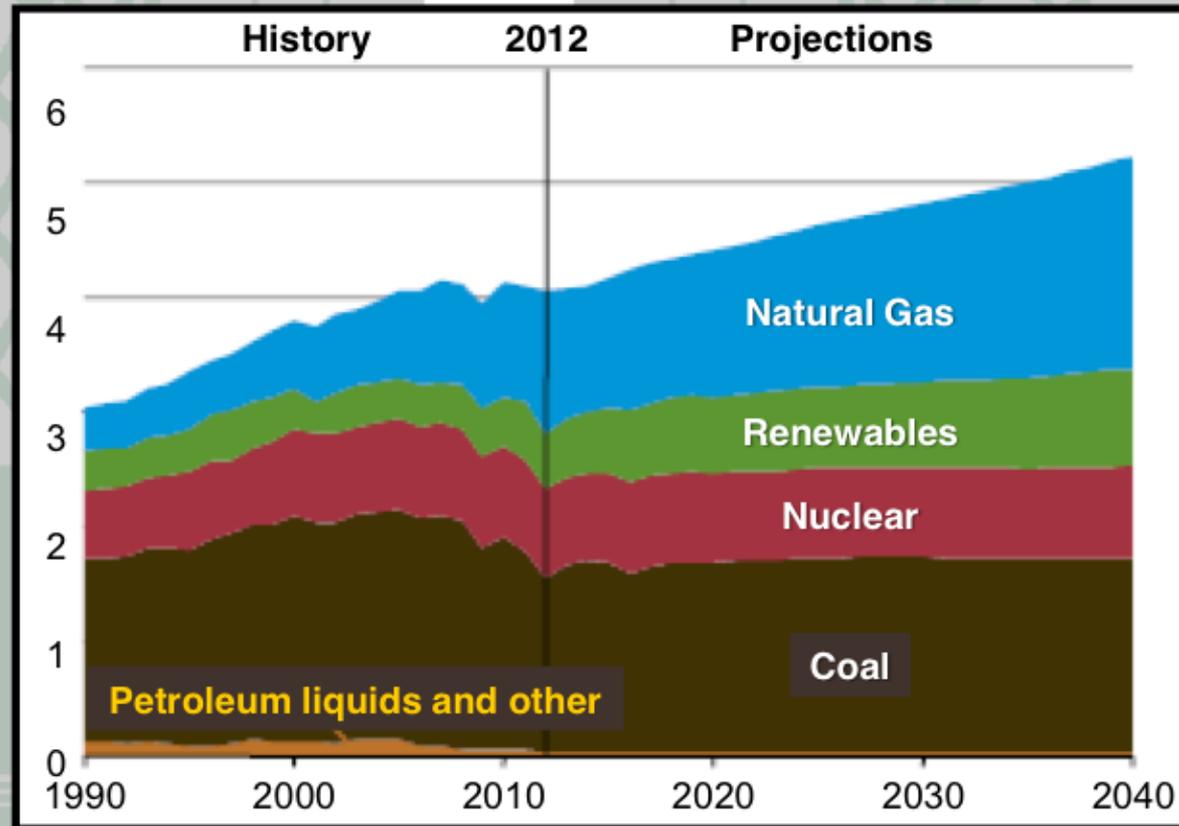


2009 to Date: 26,000 MW in Retirement Notices



US Electricity Generation Transformation

Trillion kWhs

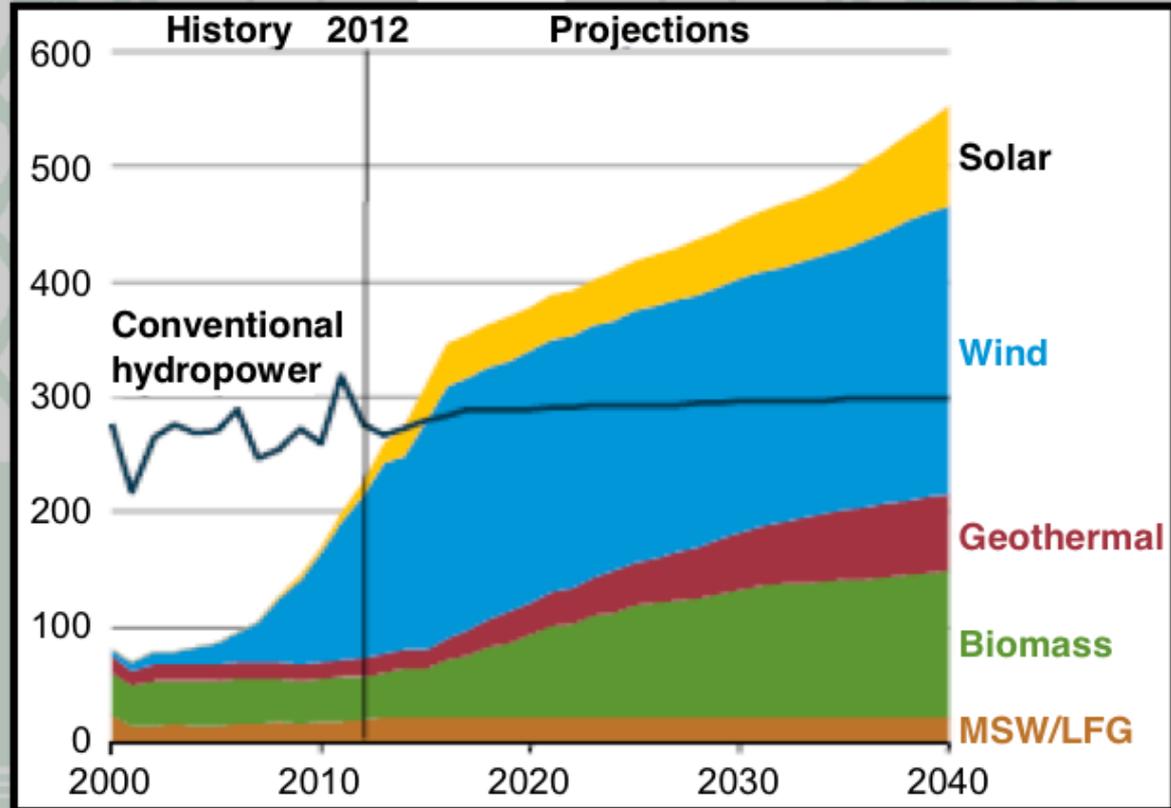


GAS Exceeds COAL in 2035; 50+ GW COAL Retired
More COAL Retirements Probable; NUCLEAR Stressed



US Electricity Generation Renewables Advance

Billion kWhs
Includes Distributed Resources

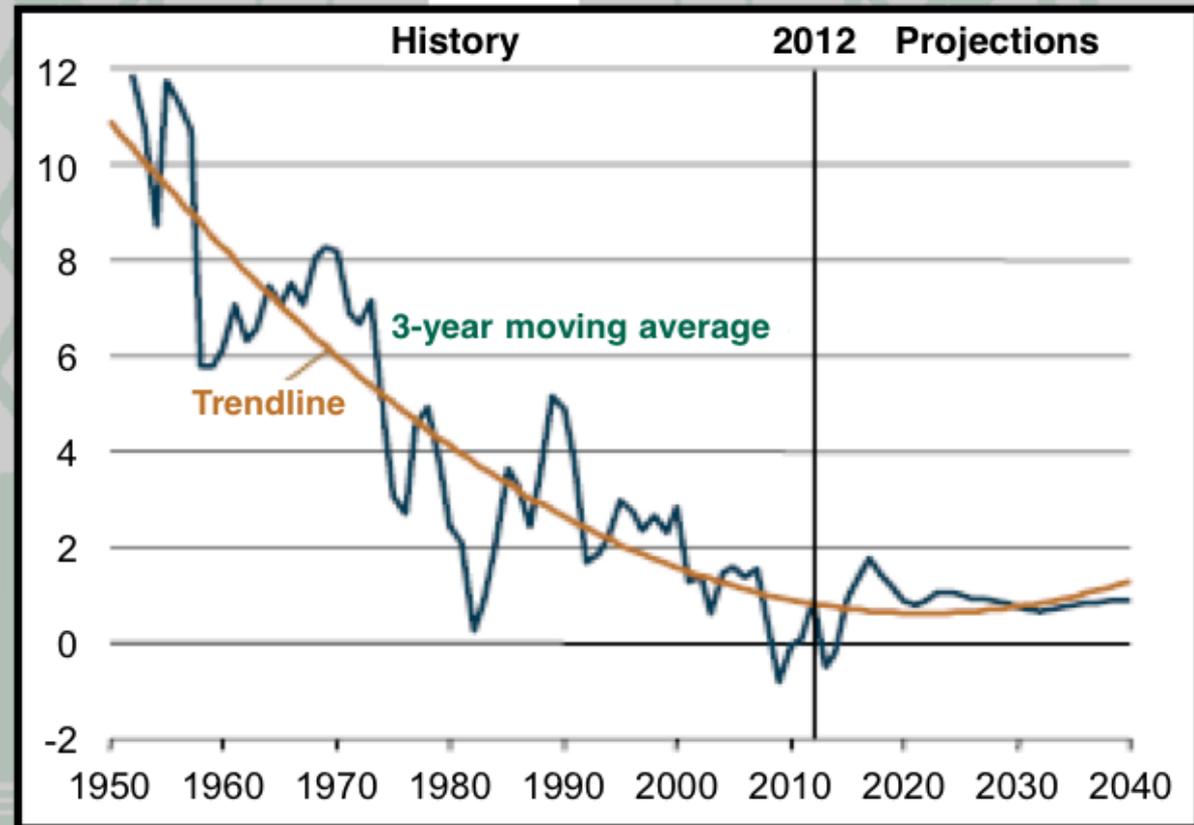


Non-Hydro Renewable Sources Grow 3.2% Annually
Game Changer – Solar Grows 7.5% Annually



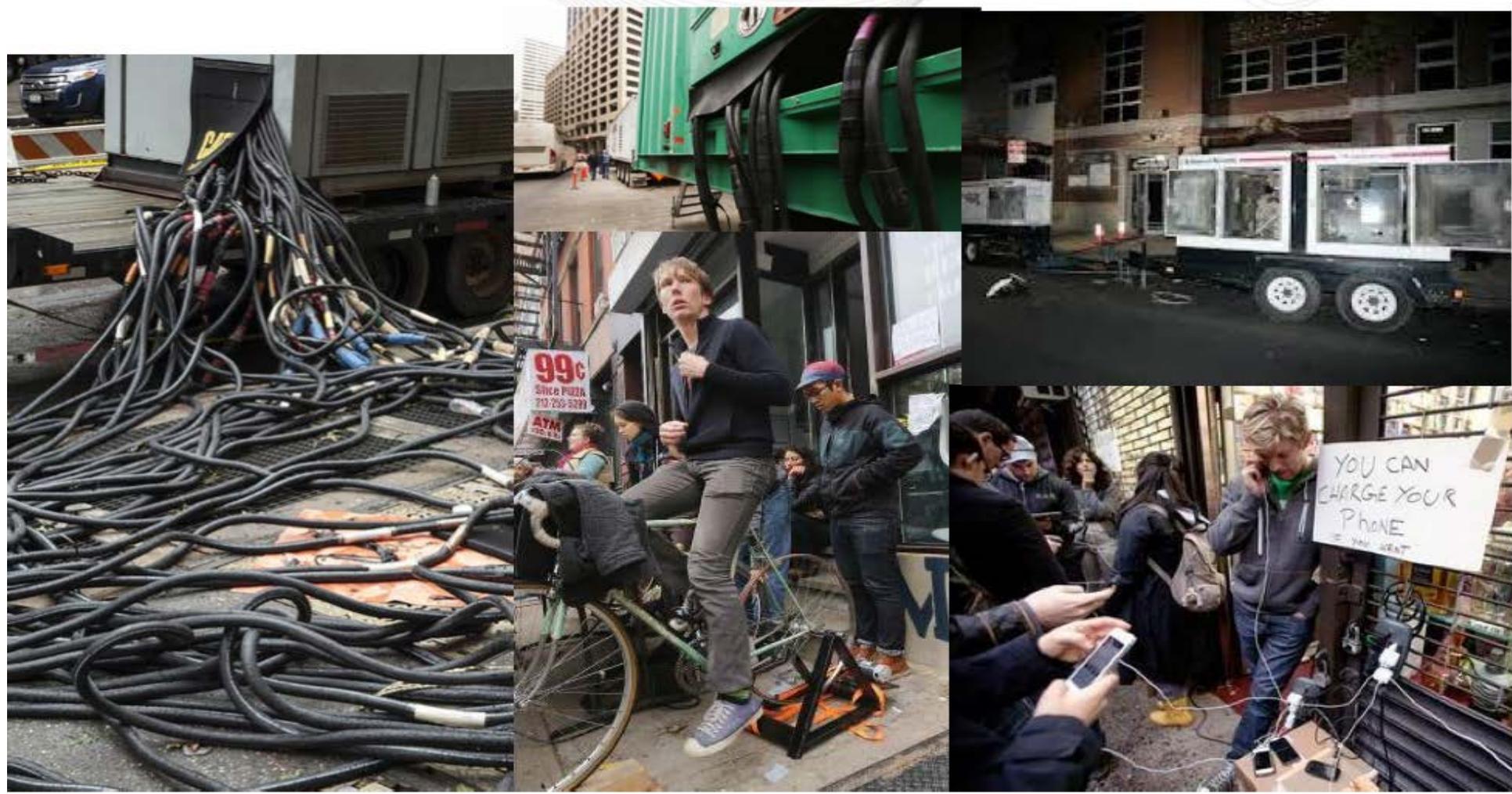
US Electricity Demand Stagnation

% Growth



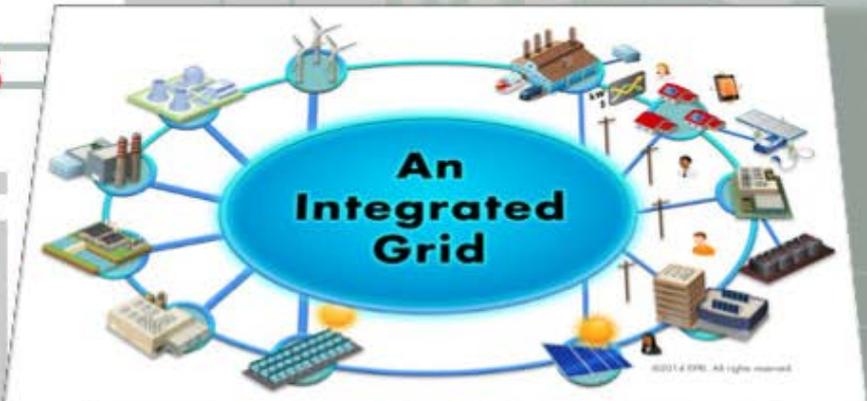
2012 to 2040 > Typical Home Down 4% (to 11.6 MWh/yr)
2012 to 2040 > Lighting Down 65%

 Microgrids ... New York City After Superstorm Sandy



Foundational Elements

- Grid Modernization
- Communications Standards
- Interconnection Rules
- Integrated Planning and Operations
- Informed Policy and Regulations



Grid Tomorrow: **21st Century Utility Business Model Welcome!**

Indian Power System : A Glimpse

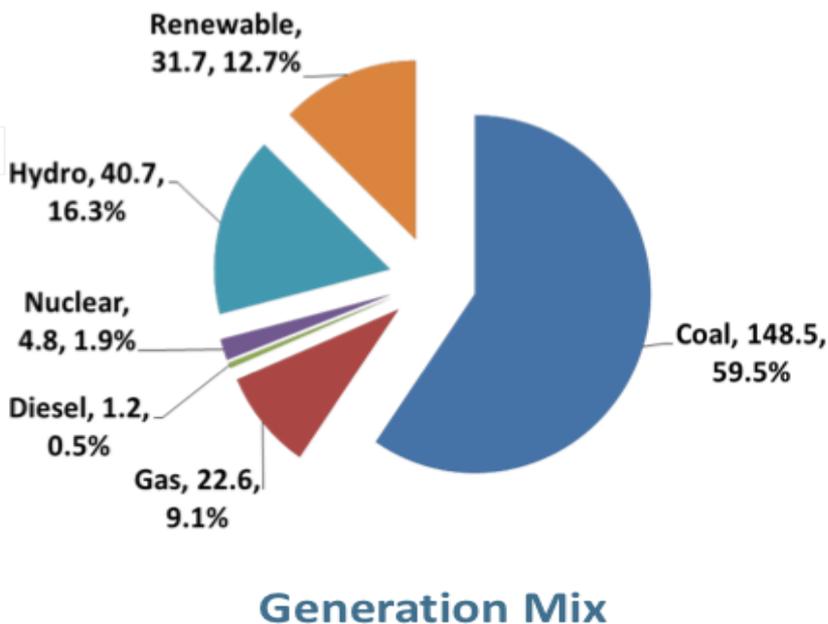
Total Installed Capacity - 249 GW

Peak Demand: 135 GW

Renewable: 31 GW

Growth Rate: 8–9 % p.a.

Figures in GW (as on 30.06.2014)



Transmission line	Existing (Jun'14)	By 2016-17*
	ckm	
1200 kV		363
765kV	12,367	32,250
400kV	127,261	144,819
220kV	145,561	170,980
HVDC Bipole (±500kV)	9,432	16,872
HVDC Bipole (±800kV)	-	1,728
Total	294,621	367,012
Transformation capacity	Existing (Jun'14)	By 2016-17*
	MVA	
765kV	88,500	174,000
400kV	180,872	196,027
220kV	258,444	299,774
HVDC	13,500 MW	225,000 MW
Total	541,316	692,301



High Capacity Transmission Corridors



NEW TECHNOLOGY INITIATIVES

1200kV UHVAC;
±800kV HVDC

High Temperature Super Conductor Line, Fault Current Limiter

Dynamic Compensation – Large and Medium size STATCOMs

Smart Transmission- Wide Area Measurement System (WAMs)

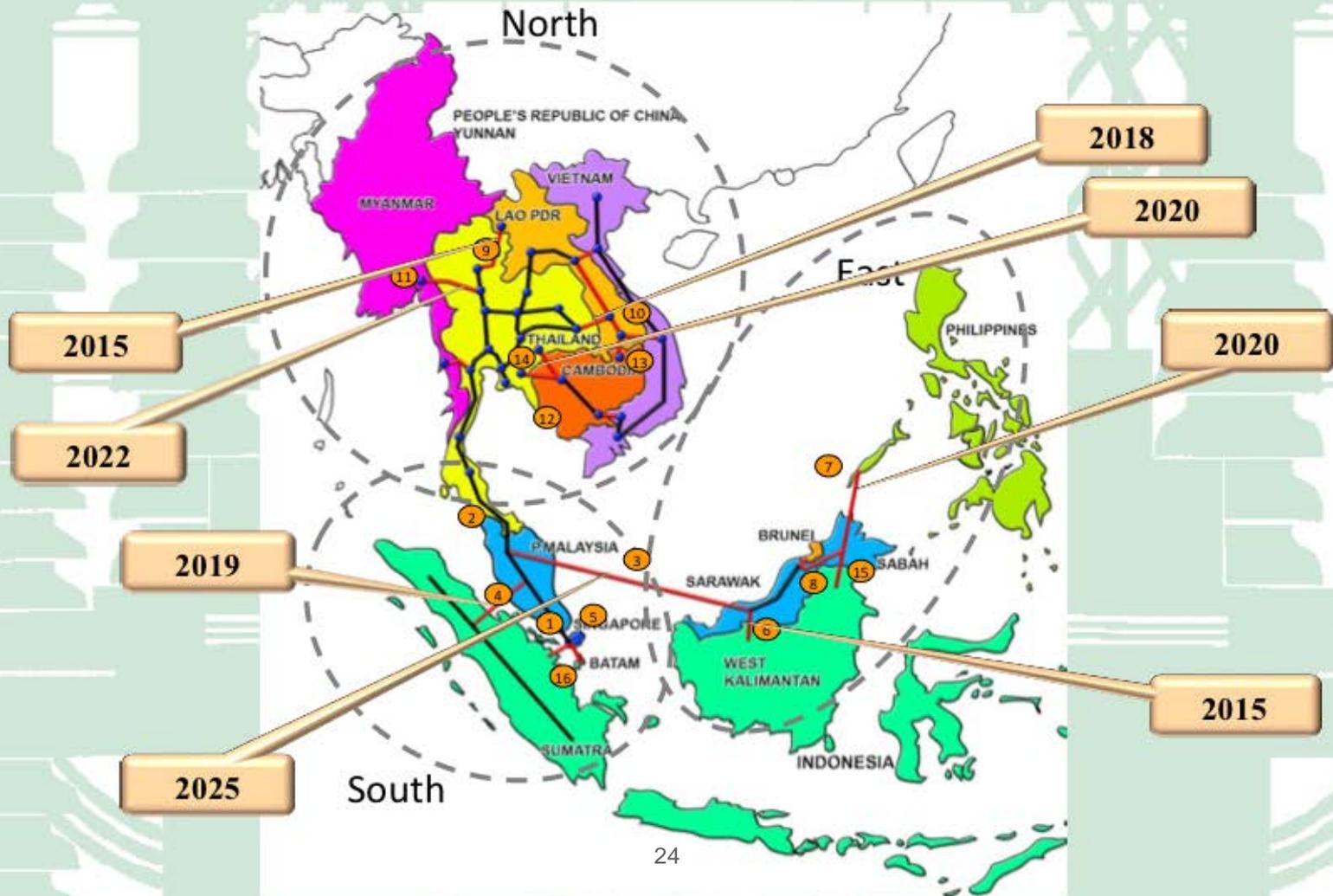
VSC based HVDC and DC Grid

Smart Grid (AMI, OMS, DSM/DR), Energy Storage



Connectivity & Collaboration (cont.)

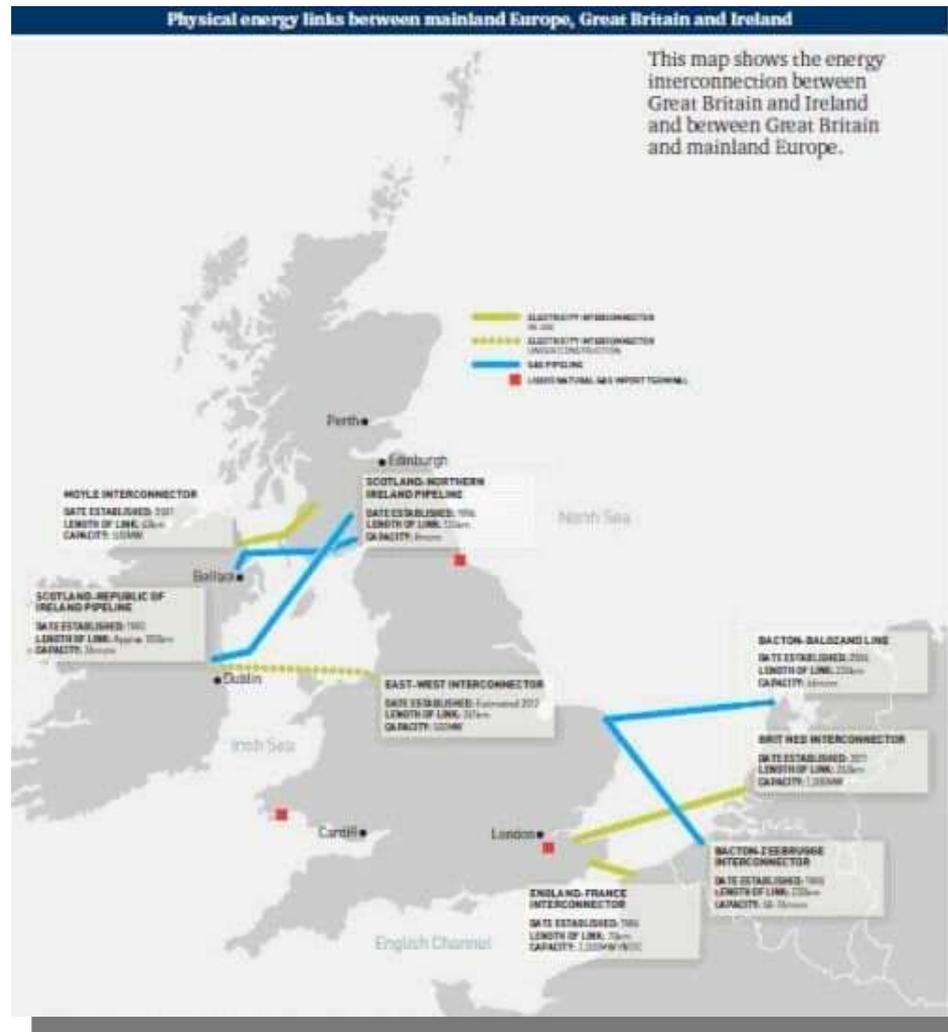
ASEAN Interconnection Master Plan



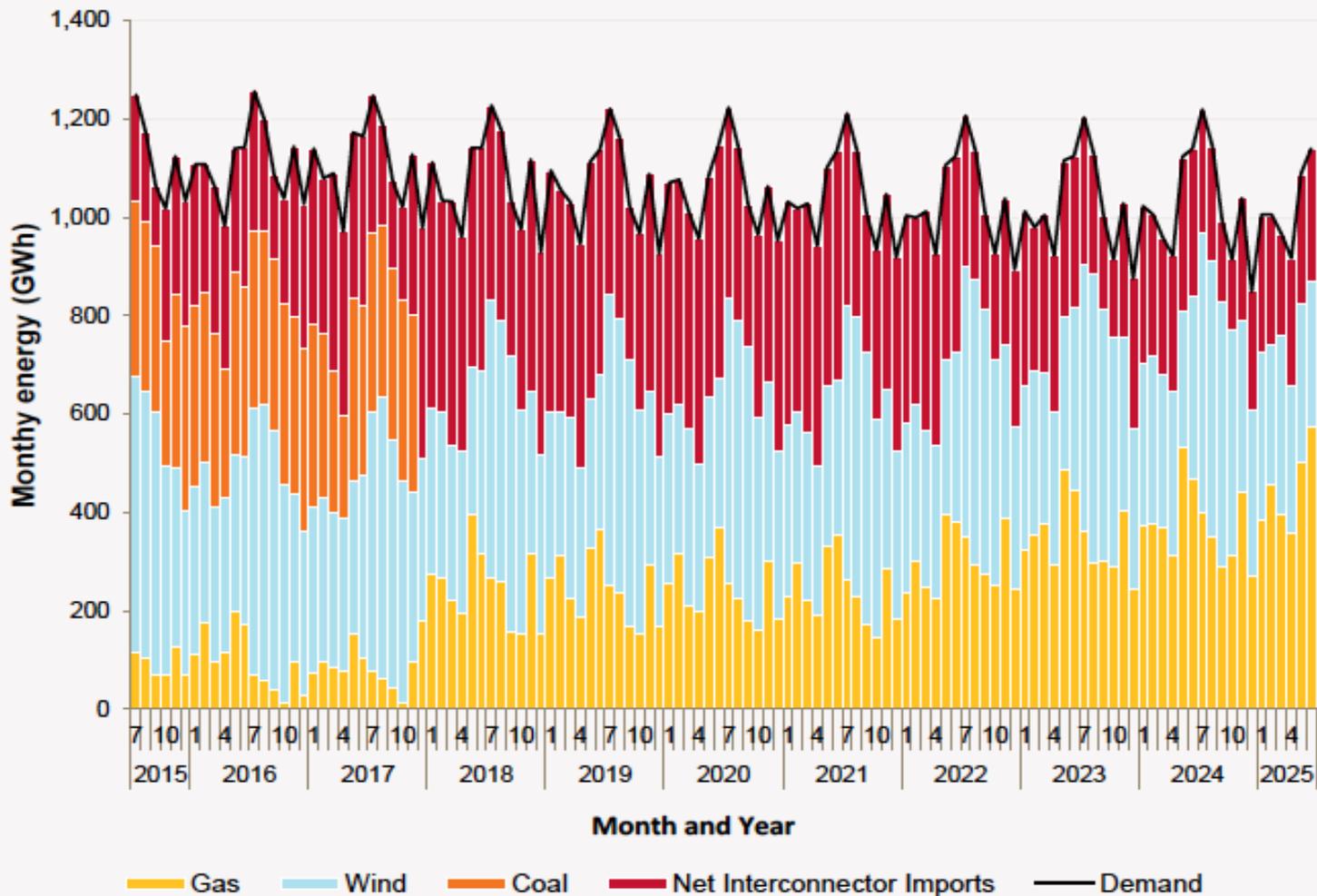
Irish Integration of Renewables



Irish Integration of Renewables



South Australia – energy generation by fuel source



A South African Township

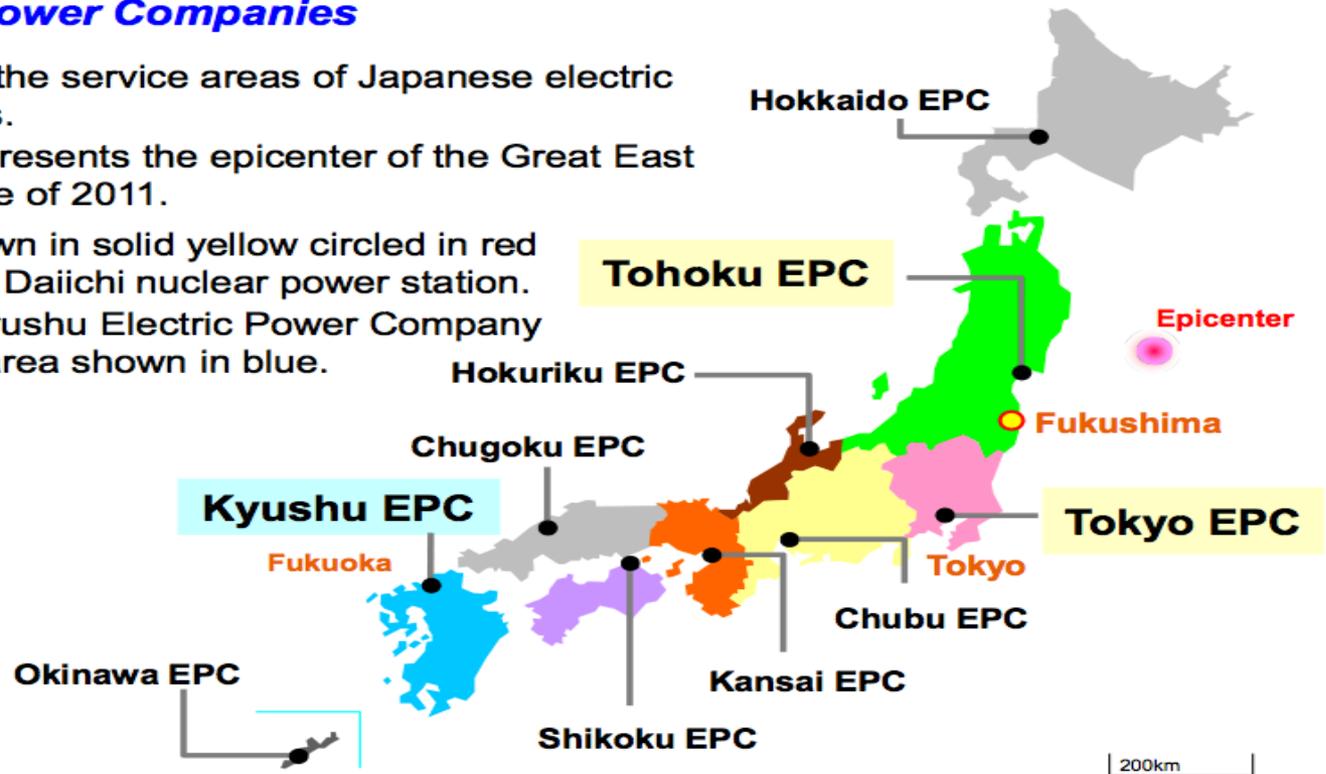


Japan Tsunami

Japanese Electric Power Companies

10 Electric Power Companies

- This map shows the service areas of Japanese electric power companies.
- The red point represents the epicenter of the Great East Japan Earthquake of 2011.
- The location shown in solid yellow circled in red is the Fukushima Daiichi nuclear power station.
- Our company, Kyushu Electric Power Company is located in the area shown in blue.

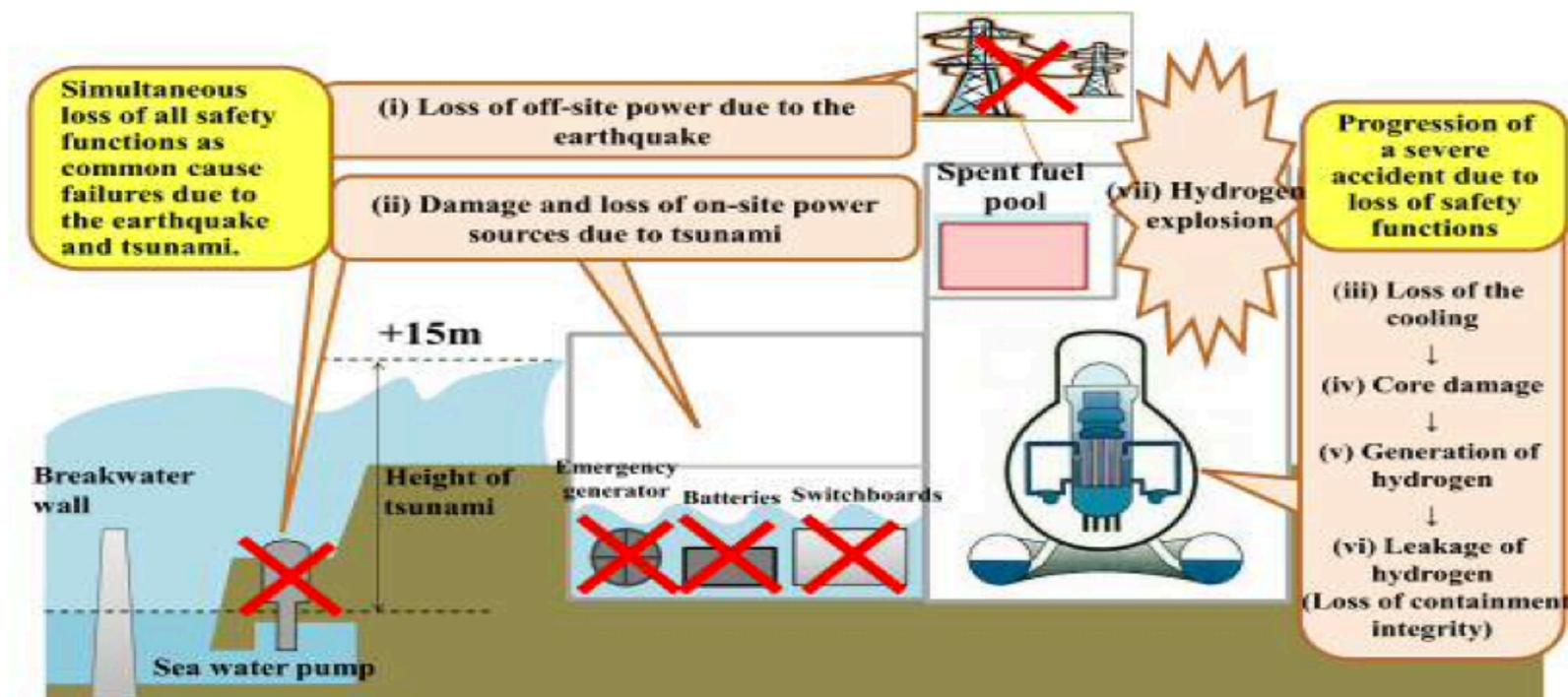


Japan Tsunami

Lessons Learned from the Fukushima Daiichi Nuclear Power Station Accident

Report-2

- All safety functions were lost simultaneously due to common causes such as earthquakes and tsunamis during the Fukushima nuclear accident.
- In addition, it was impossible to prevent subsequent progression into severe accidents

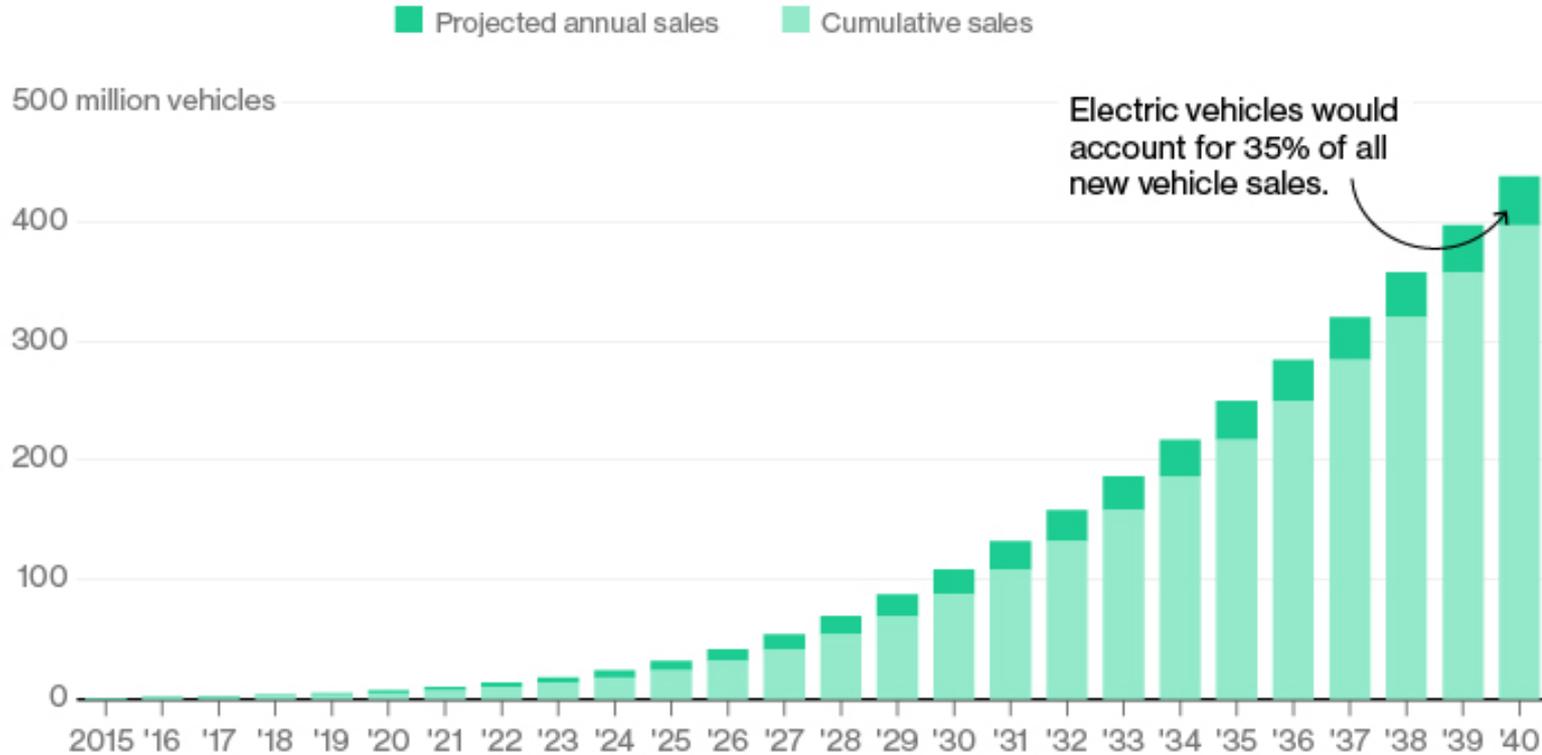


<Source: Nuclear Regulation Authority, Aug. 2013>



The Rise of Electric Cars

By 2022 electric vehicles will cost the same as their internal-combustion counterparts. That's the point of liftoff for sales.



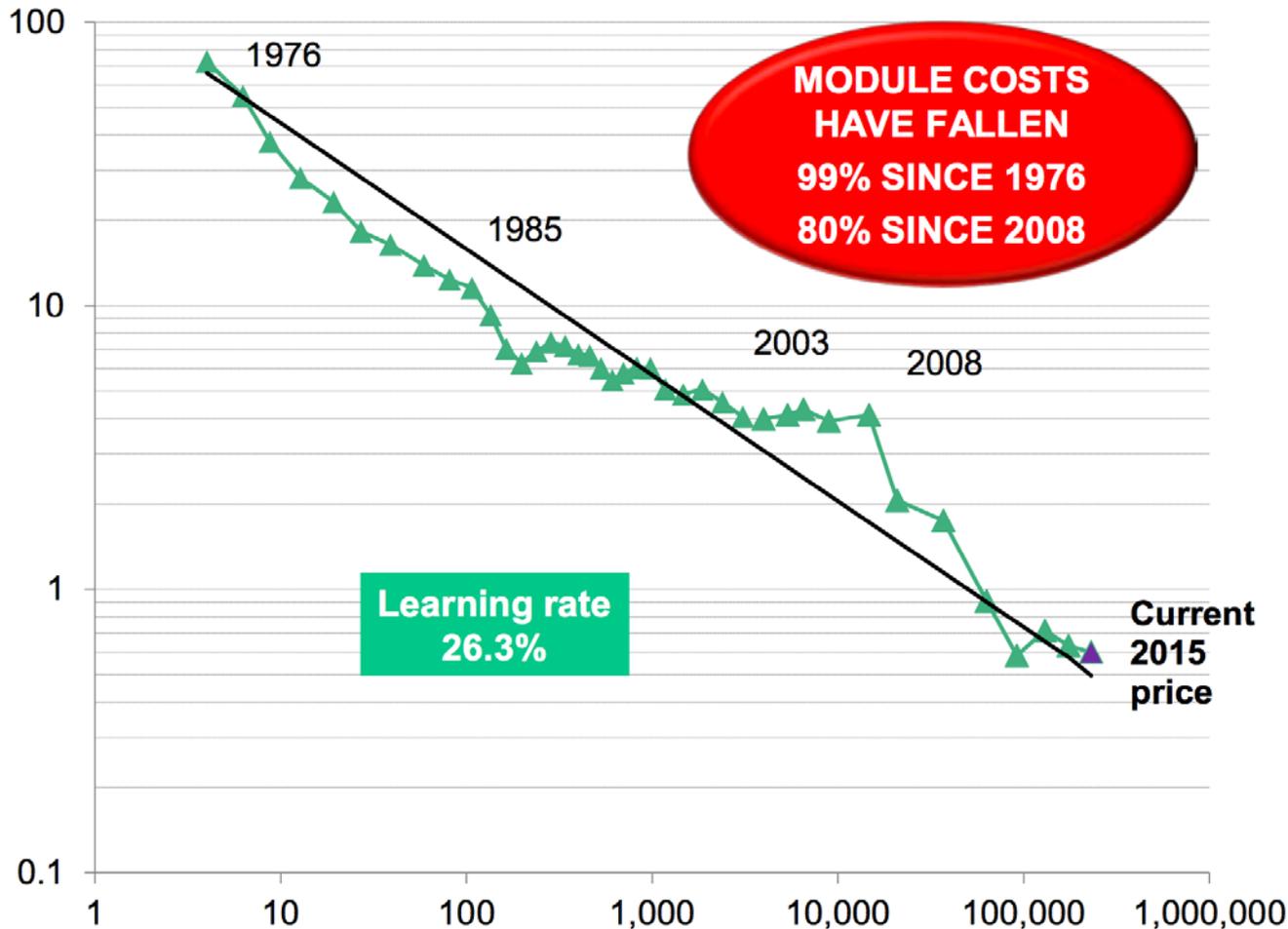
Sources: Data compiled by Bloomberg New Energy Finance, Marklines

Bloomberg 



The Beautiful Math of Solar Power

Every time the world's solar power doubles, the cost of panels falls 26%



Source: Bloomberg New Energy Finance



Global trends: Key messages



Power system stress & uncertainty due to massive renewable installation



Economically reducing pollution impact of massive growth



Shale gas as a game changer



Increasing access to electricity



Large scale interconnection for rapid power system growth



Rapidly changing technology

